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A STUDY OF LAND-USE ACTIVITIES AND THEIR RELATIONSHIP TO THE SPORT FISH RESOURCES IN ALASKA

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A STUDY OF LAND-USE ACTIVITIES AND THEIR RELATIONSHIP TO THE SPORT FISH RESOURCES IN ALASKA

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ABSTRACT

This report summarizes the first season's information collected on juvenile Dolly Varden, *Salvelinus malma* and coho salmon, *Oncorhynchus kisutch*. The emphasis of the study is placed on the value of sring-fed systems as overwintering areas, seasonal movement patterns of juvenile salmonids, effects of logging slash and debris on rearing fish habitat, and the effects of ice conditions on small streams.

Spring Pond Creek, a groundwater-fed tributary to the Starrigavin Creek drainage system, was found to have very stable temperature and water velocity regimes, while small runoff tributaries and the main stream exhibited more extreme water temperatures and velocities. Water temperatures in Starrigavin Creek neared 0° C while Spring Pond Creek never dropped below 1° C.

Dolly Varden (30.4%) and coho (27.0%) tagged with Floy FTF-69 fingerling tags, recovered in Starrigavin Creek, had moved from the original tagging site. Excluding the October fall smolt movement, 16.5% of the young char and 15.5% of the coho moved in an upstream direction, while 9.5% and 11.4% of the recaptured Dolly Varden and coho moved downstream. Tagged Dolly Varden (73.7%) and coho (72.4%) recaptured exhibited little movement. Spring Pond Creek tributary received an upstream migration of 205 Dolly Varden and 27 coho, all of which had overwintered in the stream. The estimated total in-migrant populations that overwintered in Spring Pond Creek was calculated at 440 Dolly Varden and 28 coho. In-migrant fish constituted 34.6% and 37.3% of the overwintering Dolly Varden and coho standing crop in Spring Pond Creek.

Most of the tagged Dolly Varden in-migrants at Spring Pond Creek weir originated from the main stream within 457 m (1,500 feet) upstream and downstream of the confluence of study stream and the main stream portion of Starrigavin Creek. Some char moved as far as 1,298 m (4,250 feet) in less than a month before entering Spring Pond Creek. Movement was calculated at .76 m/fish/day, (2.48 ft./day/fish). Of the tagged main stream in-migrants entering Spring Pond Creek, 62.2% originated from downstream sources, indicating a general upstream trend of movement during the fall.

Most of the in-migrant char and coho enumerated at the Spring Pond Creek weir ascended the stream in late September and early October. Upstream movement corresponded with freshets and declining water temperatures in the main stream. Upstream movement ceased by mid-November.

The overwintering population of Dolly Varden in Spring Pond Creek was composed of a mixture of rearing fish (86.6%, ages I, II, III, IV), resident and anadromous forms (13.4%, ages V, VI). The sample of coho was too small to derive any age composition information.

It was found that there are extreme differences in species composition between the rearing char and coho communities of Spring Pond Creek and other sections of the Starrigavin watershed. Most tributary streams were inhabited by large populations of coho (30-75%) while the Spring Pond Creek community is composed of 6.3% coho and 93.7% Dolly Varden. The difference in community composition may be related to the debris choked nature of the stream, but the exact factors involved are not understood.

There were detectable differences in the benthic fauna of debris laden and debris free areas of Spring Pond Creek. Debris free areas of stream usually had greater numbers of flatworms (Turbellaria); Ephemeroptera (*B. bicaudatus* and *Paraleptophlebia* sp.); Plecoptera (*Alloperia* sp.); and Trichoptera (*Rhyacophila* sp.). Debris covered areas of the stream tended to have greater numbers of Trichoptera (*Pycnopsyche* sp.) and Diptera (Chironomidae).

The food habits of Dolly Varden and coho were not representative of the fauna occurring in the type of habitat in which the fish were captured. There were also indications that food preferences existed when fish were feeding in debris covered areas. Seasonal changes in mean food consumption changed dramatically during the sample period June to December, declining from a maximum mean of 78.3 organisms per fish to 4.8 during December.

Observations of ice conditions in Starrigavin watershed revealed that sheet ice developed in quiet, slow areas of the stream when air temperatures were below 0° C for prolonged periods. Detrimental effects of ice on rearing fish were not observed, but it is believed that displacement of fish did occur in some areas when pools froze down to gravel. Frazil and anchor ice were not observed at any time during the winter.

RECOMMENDATIONS

Results of the 1973-1974 field season indicate that accumulation of logging slash and debris in small streams has an effect on the aquatic environment as shown by the difference in faunal composition in the effected areas and the lack of juvenile coho in the streams. Rearing Dolly Varden and coho were found to make considerable use of spring-fed tributaries for overwintering sites when water temperatures decline in the main stream, and for velocity shelters during floods.

Removal of streamside vegetative canopy in logging areas may depress winter temperatures causing ice conditions detrimental to juvenile fish to develop. The first winter's study on ice development did not reveal these types of icing conditions to be present.

Using the information already gathered at the Starrigavin study site as baseline information for more detailed work, we recommend the continuation of the following objectives:

1. Develop methods for a study on the effects of logging debris removal on fish populations in small streams.

2. Develop methods for the study of the value of spring-fed streams to the overwinter survival of rearing salmonids.

3. Determine methods for future research on the effects of canopy removal and ice conditions of small streams during the winter months.

4. Determine the distribution, abundance, and species diversity of the aquatic benthos fauna and its relationship to rearing fish populations.

OBJECTIVES

1. To determine the feasibility of conducting a study on the effects of logging debris removal on fish populations in small streams.

2. To determine the feasibility of conducting research on the importance of spring-fed tributaries for overwinter survival of rearing fish.

3. To establish guidelines for future research on the effects of canopy removal on temperature and ice conditions of small streams during winter months.

4. To evaluate the minnow trap as a population estimator.

5. To determine distribution, abundance, and species diversity of aquatic insects within certain types of rearing fish habitat and their relationships to rearing fish populations.

Since two of the objectives entailed the necessity of winter work, we felt it would be advantageous to locate the study on or near an existing road system.

After conducting surveys on each of the road systems in Southeast Alaska, the only area found to be suitable was the Starrigavin watershed on the Sitka road system.

The watershed, however, had been completely clearcut logged; consequently, no suitable site to conduct the canopy removal study existed. One tributary stream (Spring Pond Creek) was suitable for both the debris removal and spring-fed area studies and was selected as the primary study site.

Investigation on the effects of canopy removal was limited to background literature review and field observation of icing conditions.

Study Site Location and Description

Starrigavin watershed is located on the west coast of Baranof Island approximately 8.86 kilometers (5.5 miles) north of Sitka (Fig. 1). The watershed has recently been clearcut, with the final cutting occurring in February, 1974.

Starrigavin Creek supports runs of coho salmon; pink salmon, *O. gorbuscha*; rainbow trout, *Salmo gairdneri*; cutthroat trout, *S. clarki*; Dolly Varden; and sculpins, *Cottus* sp. The creek is approximately four miles in length and has five major tributaries (Fig. 2). Access to the watershed is provided by logging roads which run the entire length of the valley. The valley is of the U-shaped glaciated type typical of Southeast Alaska.

Considerable stream channel damage occurred during the logging operations. However, all tributaries have been hand cleared of debris, except Spring Pond Creek which, due to request, was left with the logging debris throughout.

The debris is composed primarily of thick beds 10-15 cm (4"-6") of needles and bark which upon decomposition forms a thick oozy layer of fine particulate material. Other areas of the stream are clogged with masses of branches, large logs, and pieces of fractured bark and wood. It is evident that this material is decomposing as oils and gasses rise readily to the surface when the organic beds are disturbed.

Spring Pond Creek is approximately 209 m (637 feet) in length and originates in an upwelling spring area (Fig. 3). The stream averages about .61 m (2 feet), in width and from 3 to 9 cm (7"-22") deep.

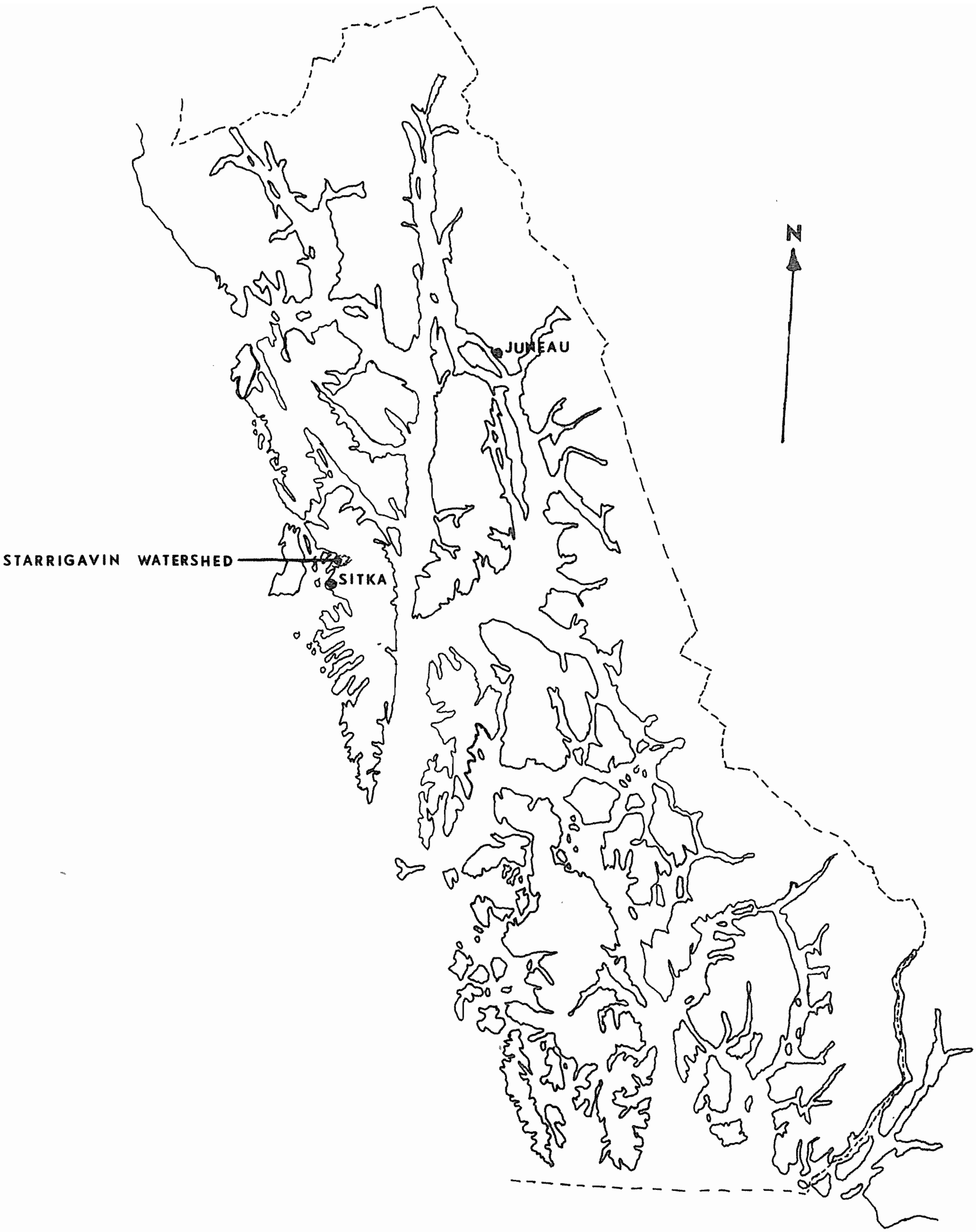

Figure 1. Location of Starrigavin Watershed Study Site.

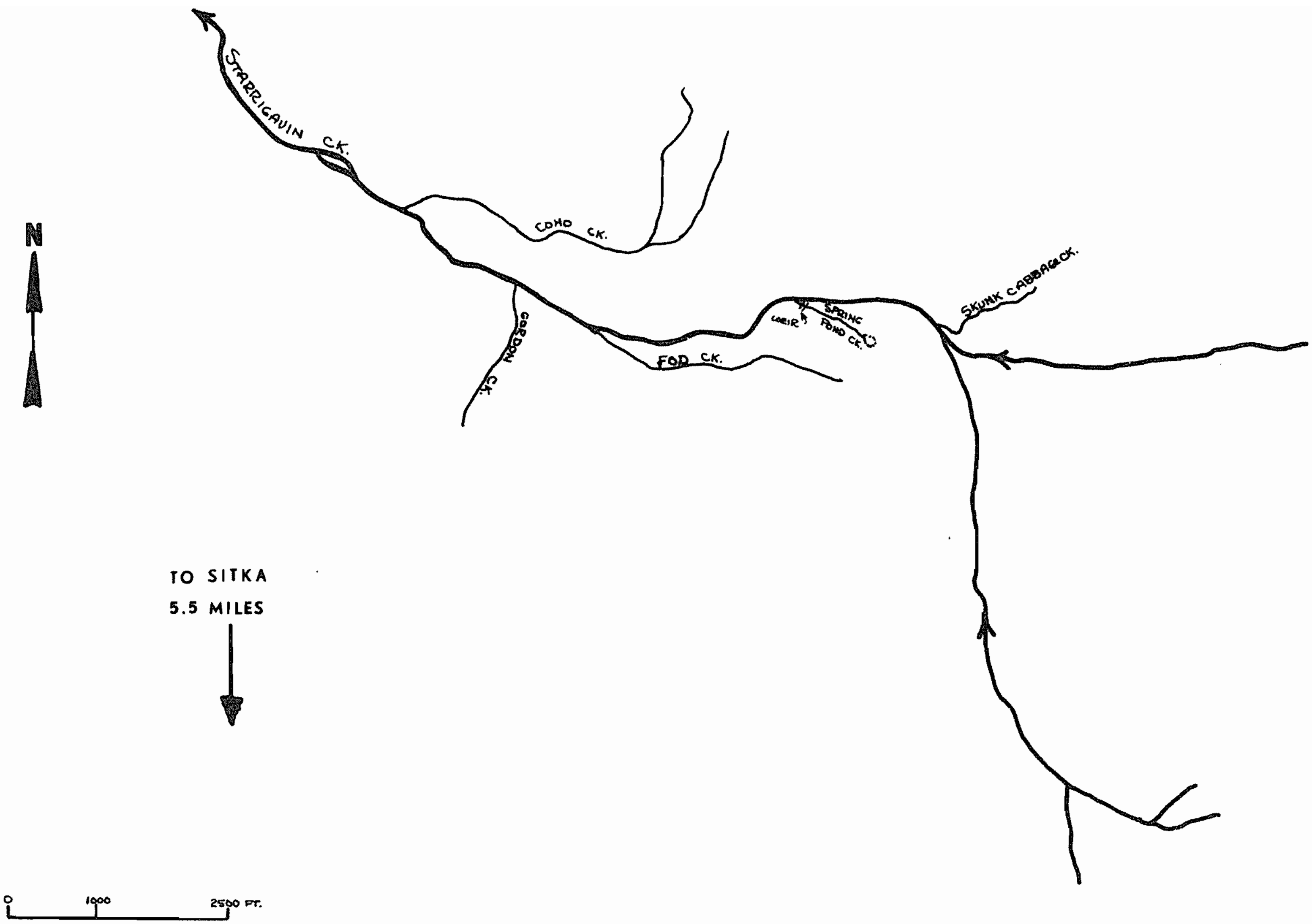

Figure 2. Starrigavin Watershed Showing Location of Major Tributaries and Weir Site.

Figure 3. Spring Pond Creek Study Site Showing Spring Pond Area in Lower Left and Tributary to Main Stream.

Figure 4. Juvenile Fish Weir Located on Spring Pond Creek, Starrigavin.

TECHNIQUES

To investigate the importance of spring-fed tributaries to the overwinter survival of rearing fish, it was necessary to monitor fish movement throughout the watershed as well as within the spring-fed area.

A small migrant fish weir was established on Spring Pond Creek approximately 23 m upstream from its confluence with Starrigavin Creek (Fig. 4) to monitor fish entering and leaving the spring-fed tributary. All fish passing through the weir were tagged with numbered Floy FT-69 fingerling tags. Information for species composition and length frequency was taken.

Monthly fish samples were taken in Spring Pond Creek to determine age, maturity, sex, and food habits. Water chemistry information and velocities were taken on a weekly basis with a Hach kit and Gurley pigmy current meter.

Continuous air and water temperature recordings were obtained with Ryan thermographs, which were placed at two places in Spring Pond Creek, three locations in Starrigavin Creek, and one in a non-spring-fed tributary (Skunk Cabbage Creek) for comparison.

To determine movement within the watershed, approximately 3,400 rearing fish consisting of coho salmon, rainbow trout, Dolly Varden, and sculpins were tagged with Floy fingerling tags throughout the watershed. Of these, approximately 1,405 juvenile Dolly Varden were given adipose clips to determine tag loss. Species type, length information, and tagging location were recorded for each fish.

Monthly trappings of the entire watershed with baited minnow traps were made to monitor movement of tagged fish.

The monthly trapping for tagged fish also enabled us to estimate the populations of rearing Dolly Varden and coho in the main stream using Chapman's modification of the Peterson formula (Ricker, 1958). These estimates were used to determine species composition of the main stream and tributary streams.

The accuracy of population estimates of main stream Dolly Varden and coho were evaluated by comparing the marked/unmarked ratio derived from each month's tag recovery samples. Given below are the marked/ unmarked ratios and percent composition of marked fish captured each month:

Marked/Unmarked		% Marked Fish	
D.V.	Coho	D.V.	Coho
.17	.05	15.14%	.05%
.21	.04	17.54%	.04%
.19	.07	16.52%	.06%
.26	.06	20.95%	.06%
.15	.04	13.17%	.04%
.11	.02	10.00%	.02%

Range: D.V. = .11-.26 10.0-20.95%
Range: Coho =.02-.07 .02-.06%

Marked/unmarked ratios for Dolly Varden and coho (especially the latter) indicate that the chance of capturing a reasonably consistent ratio of marked to unmarked fish is present. Since the range of the ratios is not considered extreme, population estimates derived from them are felt to be fairly accurate.

In addition, aquatic insect samples were taken bimonthly with a square-foot surbur sampler. These were preserved in 70% alcohol and sent to Juneau for sorting and identification. Monthly samples of rearing fish taken for stomach analysis were weighed and preserved in 70% alcohol until determination of contents could be performed.

Permanent stations were established throughout the length of Spring Pond Creek and monthly photographs were taken to document streamside vegetation recovery.

Icing conditions within the watershed were recorded when observed. Photographs were taken to document extent and type of icing encountered.

Evaluation of the minnow trap as a population estimator was obtained by comparing population estimates made with minnow traps and electroshocker. A small section of stream (68 m to 91 m) was trapped with baited minnow traps. The captured fish were enumerated, recorded as to species and marked with a partial fin clip, then returned to the stream and allowed to redistribute overnight. A recapture set was made the following morning and checked after two hours. All marked and unmarked fish were counted and returned to the test section. The section was shocked with a back-pack shocker, and a duplicate marked/ unmarked ratio was obtained. Population estimates and marked/unmarked ratios of fish obtained from both methods were compared to determine if similarities existed betweeen the two techniques.

FINDINGS

Physical and Chemical Parameters of Starrigavin Watershed

Physical and chemical measurements of stream depth, water velocity, temperature, dissolved oxygen, and pH were recorded weekly at four sites in the watershed study area: the origin and weir site on Spring Pond Creek, Skunk Cabbage Creek, and the main stream.

Skunk Cabbage Creek (Surface Water Source):

Temperatures in Skunk Cabbage Creek ranged from a high of 13° C in July and August and dropped to zero during February. Water velocities ranged from close to zero to .38 meters per second (0-1.25 ft./sec.). The pH of the stream is approximately 6.5 with a DO of 15 ppm.

Spring Pond Creek (Groundwater Source):

The two stations on Spring Pond Creek had approximately the same physical and chemical characteristics. Temperature ranged from 9.7° C to 1.0° C during the study period. Both the study origin and weir sample site had DO concentrations of approximately 14 ppm. The pH values for both sites were about 6.4. Water velocities at the weir tended to fluctuate slowly with the amount of precipitation. The velocity range was 0.13-0.30 m/sec. (0.4-1.0 ft./sec.) and an average of 0.18 m/sec. (0.59 ft./sec.).

Main Stream:

Water temperatures in the main stream ranged from 6.5° C in August to close to 0° C in late February. Water velocities fluctuated sharply with fall freshets and thaws during the winter ranging from 0.16-1.1 m/sec. (0.52-3.6 ft./sec.) at the main stream sample station. The pH was 6.6; DO was 16 ppm. The characteristics of the three streams compare as follows:

	DO	pH	Water Velocity	Temperature
Skunk Cabbage Creek	15 ppm	6.5	0-.38 m/sec.	0-13° C
Spring Pond Creek	14 ppm	6.4	.13-.30 m/sec.	1- 9.7° C
Starrigavin Main Stream	16 ppm	6.6	.16-1.1 m/sec.	0- 9.5° C

Temperature Regimes in the Starrigavin Watershed

Water temperatures of three types of streams - main stream, runoff, and groundwater spring-fed were monitored continuously during the course of the season.

All three streams had temperatures characteristic of their types (Fig. 5). Skunk Cabbage Creek, a surface water stream, experienced the highest summer temperatures reaching a maximum of approximately 13.2° C on August 21. The temperature dipped rapidly in the fall from about 11.5° C to less than 1° C within 40 days. During the rest of the winter, it fluctuated sharply with warm and cold spells, and at times was frozen solid to the substrate.

Main stream temperatures showed the same pattern of temperature changes but were less extreme than those found in Skunk Cabbage Creek. Summer temperatures rose gradually from 6.5° C in late June to a high of about 9.5° C on August 21. At this time, temperatures began a steady though less severe decline to a maintained low of 2.7° C in November. Temperatures then dropped close to 0° C in late February resulting in some of the slower sections of the stream being iced in.

Figure 5. Temperature Regimes of Skunk Cabbage Creek, Spring Pond Creek, and Starrigavin Main Stream, 1973.

Spring Pond Creek, a groundwater-fed stream, exhibited very little fluctuation, and changes in temperatures occurred very slowly. Temperatures rose from approximately 7° C in June to 9.5° C in September. In late September the temperature began to decline slowly and steadily to a recorded low of a little less than 3° C in late January. Cold snaps in February that caused massive freezing in some areas of the main stream had little effect on Spring Pond Creek, even though temperatures did approach 1° C. Thin films of surface ice measuring about .64 cm (1/4") in thickness occurred only when air temperatures were well below 0° C. From the end of September, Spring Pond Creek consistently maintained water temperatures 1.5° - 3° C warmer than the main stream and Skunk Cabbage Creek.

Spring Fed Tributaries

Population Estimates:

Population estimates of Dolly Varden, *Salvelinus malma*, and coho salmon, *Oncorhynchus kisutch*, were conducted in Spring Pond Creek and Skunk Cabbage Creek during the latter part of the field season. The mark-recapture Peterson estimate using minnow traps were used in all cases.

Estimates for Skunk Cabbage Creek were expanded by a factor of 2.4 to adjust the area sampled to equal that of Spring Pond Creek. The December estimate for Spring Pond Creek includes in-migrant fish. Estimates for the two streams are as follows:

	Spring Pond Creek		Skunk Cabbage Creek	
	Dolly Varden	Coho	Dolly Varden	Coho
August	943	37	239 (573)	221 (530)
September	1,051	75	605 (1,452)	183 (439)
November	---	--	155 (372)	346 (830)
December	1,272	103	Stream Dried Up	

( ) = Expanded Estimates

The species composition of the three tributary streams (Spring Pond, Skunk Cabbage, and Coho creeks) and the main stream of Starrigavin Creek were compared and the results indicate that the composition of the tributary streams varies considerably (Table 1).

Skunk Cabbage Creek contains approximately equal populations of Dolly Varden and coho, while both the main stream and Coho Creek tend to have dominant populations of coho. Conversely, Spring Pond Creek is dominated by Dolly Varden (93.7%) with juvenile coho composing only 6.3% of the rearing salmonid community.

Table 1. Species Composition of Tributaries and Main Stream of Starrigavin Creek, 1973.

	Dolly Varden (%)	Coho (%)
Spring Pond Creek	1,088 (93.7) *	72 (6.3) *
Skunk Cabbage Creek	799 (56.4) *	617 (43.6) *
Coho Creek	59 (25.2)**	185 (74.8)**
Main Stream	6,277 (24.2) *	19,743 (75.7) *

* Derived from estimated population
** Derived from actual catch figures

Tag Loss

Many of the fish tagged with Floy FTF-69 fingerling tags were tagged incorrectly, with the tag being positioned behind the dorsal fin. Tags should be inserted underneath the dorsal fin so as to pass through the pterygiophores. Consequently, it was felt that the fish would experience an abnormally high rate of tag loss.

Tag loss was calculated by examining captured Dolly Varden for adipose clips with the following results listed by month:

Month	No. Tag Loss	Total No. Marked Fish Captured	% Loss
October	7	23	30.4
November	2	20	6.6
December	8	21	38.0
January	13	35	37.1
February	5	20	25.0
March	3	11	15.0
Total	38	130	29.23

Movement of Fish in the Main Stream

Tag recaptures in the main stream of Starrigavin watershed indicated that the majority of Dolly Varden (64.6%) and coho (72.49%) underwent little movement during the sample period of August to January (Table 2).

Of the tagged Dolly Varden captured, 35.4% had moved from the original tag site and 27.03% of the juvenile coho exhibited movement; indicating slightly greater tendency for char to move than coho. Both upstream and downstream movement did not appear to be localized in any particular area but occurred throughout the system simultaneously.

In October, there was a greater percentage of Dolly Varden moving downstream than at any other time during the sample period, but there

Table 2. Tag Recoveries and Direction of Movement of Dolly Varden and Coho in Main Stream of Starrigavin Creek, 1973.

	Dolly Varden*				Coho*			
	Upstream	None	Downstream	N	Upstream	None	Downstream	N
Aug. & Sept.	28(17.84)	120(76.43)	9(5.73)	157	8(47.06)	9(59.94)	0	17
October	38(14.34)	147(55.47)	80(30.19)	265	4(5.71)	59(84.29)	7(10.00)	70
Nov. & Dec.	8(9.20)	68(78.16)	11(12.64)	87	7(19.44)	22(61.12)	7(19.44)	36
January	8(36.36)	8(36.36)	6(27.28)	22	4(16.00)	18(72.00)	3(12.00)	25
	82(15.44)	343(64.60)	106(19.96)	531	23(15.54)	108(72.97)	17(11.49)	148

* (Percent)

Table 3. Distance and Rate of Movement of 22 Dolly Varden Captured at Spring Pond Creek Weir, 1973.

	Downstream						Upstream		
Section Tagged In	004	007	008	009	010	013(Weir)	011	012	014
Distance From Section to Weir (feet)	4250	2970	2640	1650	1000	250	500	1500	2500
Days Required	28	35	45	29	30	33	47	27	42
Number Fish (%)	1(4.54)	3(13.63)	2(9.09)	3(13.63)	5(22.73)	2(3.09)	3(13.63)	2(9.09)	1(4.54)

Distance traveled/day/fish = 2.48

appeared to be no detectable increase in movement of coho. Eighty Dolly Varden (30.19%) of the tagged fish captured in October had moved downstream from their original tag site. This is believed to be a fall smolt out-migration; length frequency and age analysis should substantiate this.

Fall smolt movement is considered separately as it shares little behavioral similarities with movement of non-smolt rearing fish. Examination of movement of juvenile char, excluding smolt movement, shows that 16.5% of the non-smolt recaptures during the sample period moved in an upstream direction while only 9.8% of the juvenile char moved downstream; 196 char or 73.17% exhibited no movement.

Coho also showed a greater tendency for upstream movement with 15.5% moving upstream and 11.4% moving downstream.

Tagged main stream Dolly Varden captured at Spring Pond Creek weir were primarily from downstream sources (Table 3). Of the main stream in-migrants, 72.8% originated downstream of the weir and 27.2% from upstream sources.

The distance and time required for the movement of in-migrant Dolly Varden captured at Spring Pond weir was calculated. Most of the in-migrants (62.2%) originated from the main stream approximately 457 m (1,500 ft.) upstream and downstream of Spring Pond Creek (Table 3), but some individuals moved as far as 1,296 m (4,250 ft.) in less than a month's time. Volitional upstream movement of Dolly Varden was calculated at 0.76 m (2.48 ft.)/day/fish.

It is believed that much of the upstream movement in the Starrigavin system is attributed to the search for overwintering sites such as small tributary streams that offer shelter from freshets and declining main stream temperatures. Table 4 presents tag recovery data from tributary streams in the Starrigavin watershed. Both Skunk Cabbage Creek and Spring Pond Creek have significantly high numbers of tag recoveries from main stream sources. Fod Creek, Gordon Creek, and Coho Creek were sampled late in the season and though the data is considered incomplete, it does suggest that volitional upstream movement also occurs in these streams.

Skunk Cabbage Creek, a runoff stream, dried up and froze in December. Tag recoveries made later in the season indicated that fish in Skunk Cabbage Creek moved out of the stream and overwintered in other tributaries and in the main stream.

Movement of Fish at Spring Pond Creek Weir

Since initiation of weir operations at Spring Pond Creek on September 20, 1973, a total of 316 Dolly Varden and 31 juvenile coho were enumerated. Fish moving through the weir were divided into four categories: in-migrants from the main stream, in-migrants that originally came from Spring

Table 4. Tag Recoveries of Dolly Varden and Coho in Starrigavin Tributary Streams, 1973.

	Downstream Source		Upstream Source		No Movement		Total Recapture	
	D.V.	Coho	D.V.	Coho	D.V.	Coho	D.V.	Coho
Coho Creek	0	0	3	0	0	6	3	6
Gordon Creek	0	2	0	0	-	-	0	2
Fod Creek	0	2	1	0	-	-	1	2
Skunk Cabbage Creek	22	0	4	0	16	12	42	12
Spring Pond Creek	29	0	3	0	119	9	151	9

Pond Creek, out-migrants from Spring Pond Creek, and in-migrants that ascended Spring Pond Creek then returned to the main stream within a 24-48 hour period. Fish that ascended Spring Pond Creek and took up residence were called in-migrants. Likewise, those that moved out and did not return were called out-migrants. Fish that moved up and down the creek, passing the weir each time were called temporary residents.

Of the 300 Dolly Varden (Table 5) that ascended Spring Pond Creek, 211 (67.1%) overwintered in the stream while 58 (24.1%) left the stream within 24 hours and an additional 21 (8.7%) left within 48 hours. Only 16 Dolly Varden out-migrated from Spring Pond Creek and did not return. However, 12 of these out-migrants originated from the main stream trunk of Starrigavin Creek, while only 4 came from Spring Pond Creek.

A total of 30 in-migrant juvenile coho were counted at the Spring Pond Creek weir. Twenty-eight (87.5%) in-migrated and overwintered in the stream while two (12.5%) left within 48 hours. Only one out-migrant coho was counted at the weir.

Factors involved in the oscillating movement of Dolly Varden through the weir are not understood. It is felt that some may belong to a localized community of juvenile fish which are constantly moving. This community probably encompasses all of Spring Pond Creek and adjacent sections of the main stream in close proximity to the study stream. However, the debris laden nature of the stream and competition with fish already occupying territories may also be factors in the oscillating movement observed at the weir.

Excluding temporary residents, there was a net increase of 205 juvenile Dolly Varden and 27 coho to the population of Spring Pond Creek, an increase of 16% and 26% to the estimated standing crop of Dolly Varden and coho, respectively.

If we assume that the ratio of tagged main stream fish to unmarked main stream fish moving into Spring Pond Creek and recorded at the weir is representative of the ratio of tagged to untagged fish that moved into Spring Pond Creek prior to weir construction, then it is possible to estimate the number of in-migrant fish that moved into the creek before September 20. Using the expression:

$$N_{DV} = \frac{(U)\ (M_1)}{M_2} + M_1$$

where N = Number of unmarked char entering and residing before weir construction

U = Number unmarked char entering and residing after weir construction

M_1 = Number marked char counted in creek prior to weir

M_2 = Number marked char counted through weir

$$N_{DV} = \frac{(190)\ (14)}{(12)} + 14 = 235$$

Table 5. Numbers and Percent Composition of Dolly Varden and Coho Entering and Leaving Spring Pond Creek During the Period September 20, 1973 - December 4, 1973.

	Mainstream Origin		Spring Pond Creek Origin		Total	
	Dolly Varden	Coho	Dolly Varden	Coho	Dolly Varden	Coho
Inmigrants	202(91.4%)	26(92.8%)	19(9.6%)	22(7.2%)	221	28
Outmigrants	12(75.0%)	1(100%)	4(25.0%)	0	16	1
Temporary Residents*						
Residing 24 hours	50(20.8%)	1(6.2%)	8(3.3%)	0	58(24.1%)	1(6.2%)
Residing more than 25 hours	20(8.3%)	1(6.2%)	1(.41%)	0	21(8.7%)	1(6.2%)
Total Temporary Residents	70(29.1%)	2(12.5%)	9(3.7%)	0	79(32.9%)	2(12.5%)

* Expressed in percent of total immigrants

No marked coho were captured in Spring Pond Creek prior to weir construction so an estimate of pre-weir in-migrants could not be made.

Considering the above figure, it is estimated that a total of 440 Dolly Varden migrated into Spring Pond Creek during the early fall months. This results in a 34.6% increase in the population of char since August.

There was a corresponding increase in the coho population with a total of 28 coho entering, increasing the estimated population by 37.3%.

Timing of Movements

There were two major periods of movement exhibited by the 533 Dolly Varden captured at Spring Pond Creek weir: the last week in September and the second week in October (Fig. 6).

General upstream movement was probably elicited by declining water temperatures in the main stream. Both Dolly Varden and coho continued to move into Spring Pond Creek from September to about the 10th of November. At this time the main stream water temperature reached approximately 3° C, declining from a high of about 6.5° C in late August (see Fig. 5).

Water velocity also affected upstream movement into Spring Pond Creek. A freshet in Starrigavin Creek on October 8 resulted in a surge of movement into the study stream. Though the water depth increased in Spring Pond Creek, its velocity was negligible compared to that of the main stream and, therefore, is of considerable value as a velocity shelter.

A total of 93 Dolly Varden in-migrants were counted during the last week in September. At the same time, there was a corresponding out-migration of 91 Dolly Varden. Analysis of tag numbers showed that 30.8% of the 91 Dolly Varden that left the stream in the last week in September returned and moved back into Spring Pond Creek during the October 8 freshet and comprised approximately 43.0% of that particular in-migration.

Movement of char ceased by mid-November with only three Dolly Varden being enumerated between November 7 and December 8.

Composition of the Overwintering Population in Spring Pond Creek

It was noted that many of the Dolly Varden which moved upstream in November and December were anadromous spawners, some as large as 300 mm.

These fish were evidently able to spawn successfully, as developing eggs were discovered in some of the debris-free areas later during the winter.

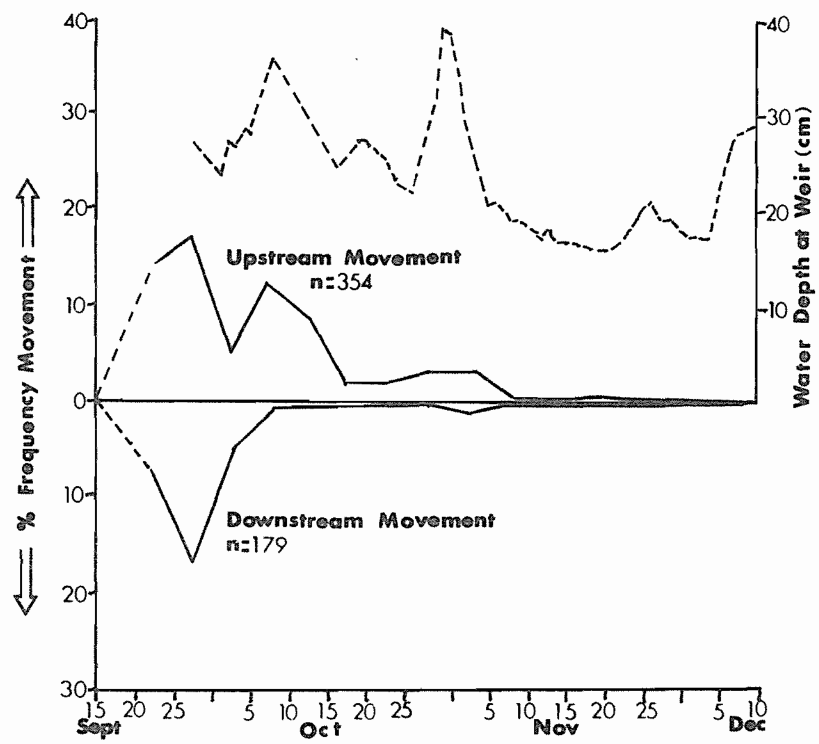

Figure 6. Percent Frequency Movement and Timing of Juvenile Dolly Varden at Spring Pond Creek Weir Compared to Water Depth, 1973.

In-migrant Dolly Varden entering Spring Pond Creek were measured and tagged at the weir. Analysis of length frequencies shows that fish passing into the Creek during the time period of September to December, were larger than both indigenous fish in Spring Pond Creek and juveniles in the main stream (Fig. 7). Seasonal analysis of length frequency shows that the mean length of the Dolly Varden population living in Spring Pond Creek increased from June to December, a result of the relatively large size of the in-migrant fish:

	May	June	September	October	November	December
$\bar{X}$	107	84	84	111	108	110
N	27	3	23	111	6	6

Analysis of age and length indicates that the overwintering population of Dolly Varden living in Spring Pond Creek was a mixture of rearing char, spawning resident chars, and a small number of anadromous spawners (Table 6).

The greatest portion of the overwintering population was rearing char (86.6%) equally dispersed in age groups I, II, III, and IV, with the remainder (13.4%) of the overwintering population being composed of ages V, VI, and VII (resident and anadromous forms).

Composition of the Benthos

Analysis of the benthic fauna resulted in two distinct faunal communities (Tables 7 and 8). Both organic (detrital ooze and emergent decaying slash) and gravel substrates were dominated by species belonging to the family Chironomidae. However, the epibenthic fauna differs considerably with the gravel substrates having a greater composition of forms such as *Baetis bicaudatus* Dodds and *Paraleptophlebia* sp. (Ephemeroptera); *Nemoura* sp., *Alloperla* sp. (Plecoptera); and *Rhyacophila* sp. (Trichoptera).

Epibenthic organisms commonly found on organic substrates include a high number of *Pycnopsyche* sp. (Trichoptera) and *Dicranota* sp. (Tipulidae: Diptera).

Undoubtedly, there is a great deal of mixing of the two benthic communities through downstream drift. How this affects the compositions of each fauna is not known.

Benthic Fauna and Food Habits of Young Dolly Varden

Benthos samples in Spring Pond Creek revealed that areas with exposed gravel supported higher numbers of Ephemeroptera (mostly *Babicandatus* sp.) and Plecoptera (mostly *Alloperla* sp.) than did areas covered with slash and debris material. Conversely, debris-littered areas supported

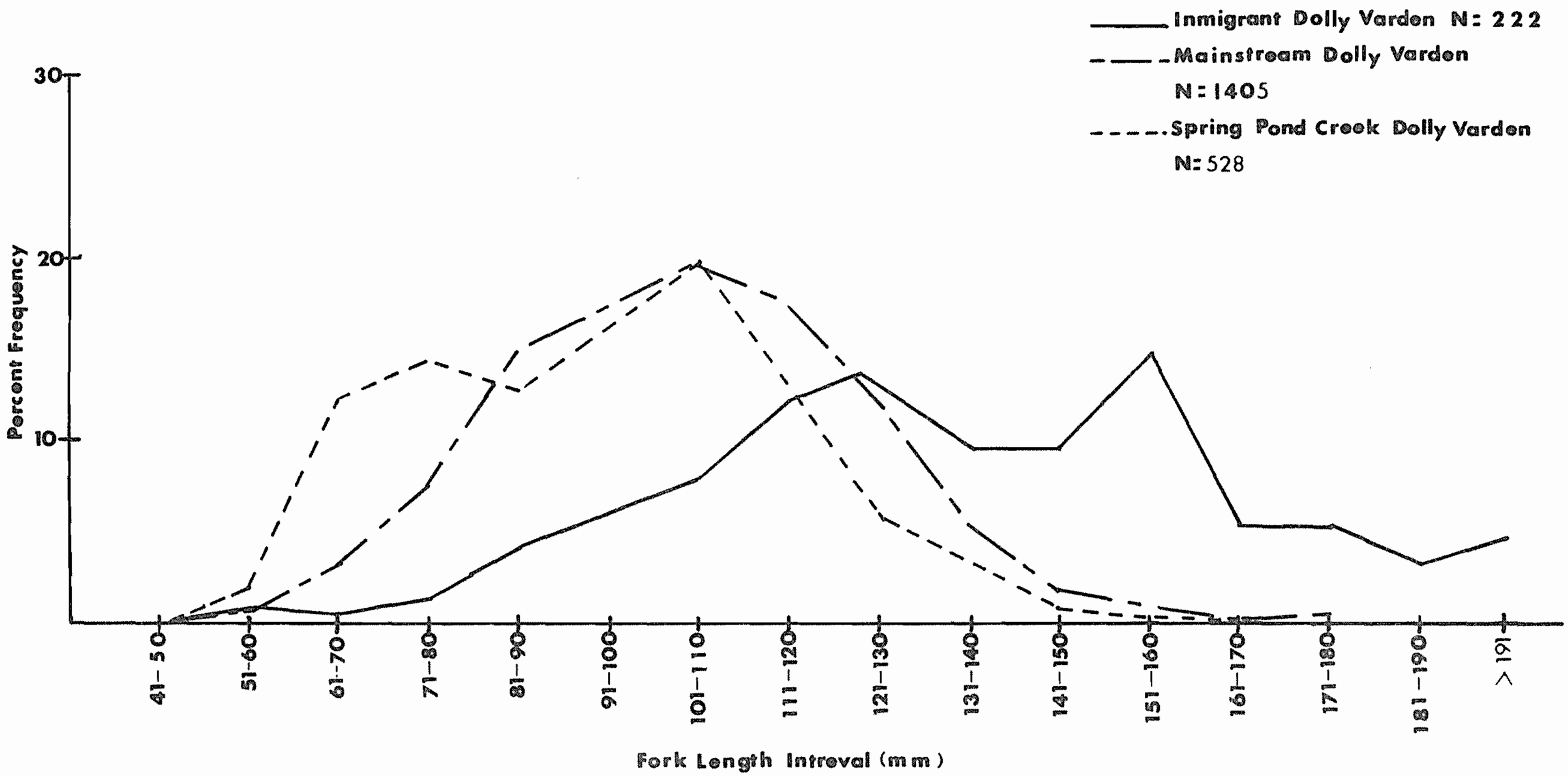

Figure 7. Length Frequencies of Juvenile Dolly Varden in Starrigavin Watershed, 1973.

Table 6. Age-Length Composition of Overwintering Dolly Varden.

Age	N	$\bar{X}$ FL (mm)	Range (mm)	% Composition
I	15	73.2	59-95	28.9
II	13	93.8	70-111	25.0
III	12	104.7	84-122	23.1
IV	5	125.8	112-139	9.6
V	5	123.4	110-149	9.6
VI	2	160.0	155-165	3.8

Table 7. Composition of the Benthos in Spring Pond Creek, 1973.

	Gravel Substrates			Organic Substrates		
	No.	% Comp.	% Freq.	No.	% Comp.	% Freq.
Turbellaria	26	3.31	30.00	6	.86	2.14
Oligochaeta	4	.51	20.00	4	.57	14.2
Pelecypoda	--	--	--	7	1.00	28.5
Ameletus sparsatus	--	--	--	2	.28	7.14
Baetis bicaudatus	64	8.14	60.00	16	2.30	35.7
Cinygmula sp.	3	.38	90.0	20	2.89	35.7
Paraleptophlebia sp.	22	2.79	20.0	2	.28	21.4
Ephemerella (D.) grandis	1	.13	10.0	--	--	--
Nemoura sp.	39	4.97	70.0	35	5.06	57.1
Leuctra sp.	2	.25	20.0	--	--	0
Capnia sp.	2	.25	10.0	6	.86	28.5
Alloperla sp.	40	5.09	70.0	4	.57	14.2
Rhyacophila spp.	39	4.96	80.0	9	1.30	35.7
Pycnopsyche sp.	--	--	--	35	5.07	50.0
Micrasema sp.	--	--	--	1	.14	7.14
Dicranota sp.	19	2.42	60.0	37	5.36	71.4
Palpomyia sp.	--	--	--	--	--	--
Chironomidae 12spp.	518	65.91	100.0	498	72.17	100.0
Chironomidae pupae	1	.13	20.0	8	1.15	14.2
Simuliidae	6	.76	30.0	1	.14	7.1
Atherix sp.	--	--	--	--	--	--
Total	786	100%		690	100%	
n =	10			14		

Table 8. List of Benthic Organisms Found in Spring Pond Creek, 1973.

- Turbellaria
- Oligochaeta
- Acarina
- Ostracoda
- Insecta
  - Ephemeroptera
    - Siphlonuridae
      - *Ameletus sparsatus* Mcd.
    - Baetidae
      - *Baetis bicaudatus* Dodds
    - Heptageniidae
      - *Cinygmula* sp.
    - Leptophlebiidae
      - *Paraleplophlebia* sp.
    - Ephemerellidae
      - *Ephemerella (Drunella) grandis flavitincta* Mcd.
  - Plecoptera
    - Nemourinae
      - *Visoka cataractae* (Neave)*
      - *Zapada haysi* (Ricker)*
    - Capniinae
      - *Capnia melia* Frison*
      - *Capnia nana* Claassen*
    - Leuctrinae
      - *Despaxia augusta* (Banks)*
    - Chloroperlidae
      - *Suwallia pallidula* (Banks)*
  - Trichoptera
    - Rhyacophilidae
      - *Rhyacophila vepulsa* ? Milne
      - *Rhyacophila* sp.
    - Limnephilidae
      - *Pycnopsyche* sp.
    - Brachycentridae
      - *Micrasema* sp.
  - Diptera
    - Tipulidae
      - *Dicranota* sp.
    - Ceratopogonidae
      - *Palpomyia* sp.
    - Chironomidae
      - Tanypodinae
        - *Pentaneura* sp.
      - Diamesinae
        - *Diamesa* sp. A
        - *Diamesa* sp. B
        - *Diamesa* sp. C
        - *Pseudodiamesa* c.f. *arctica* Malloch
        - *Prodiamesa* c.f. *olivacea* Meigan

Table 8. (cont.) List of Benthic Organisms Found in Spring Pond Creek, 1973.

- Orthocladiinae
  - *Brillia* sp.
  - *Heterotrissocladius* sp.
  - *Orthocladius* sp.
  - *Paraphaenocladius* sp.
- Chironominae
  - *Polypedilum* sp.
  - *Micropsectra* sp.
- Simuliidae
  - *Prosimulium* sp.
  - *Cnephia* sp.
  - *Simulium* sp.
- Rhagionidae
  - *Atherix* sp.

* Collected as adults

greater numbers of Trichoptera (*Pycnopsyche* sp.) and Diptera (*Dicranota* sp. and Chironomidae).

Fish were collected for food habit determination from debris free and debris covered areas of Spring Pond Creek and their stomach contents compared. The sample of coho, due to the low population in Spring Pond Creek, was too small to draw any conclusions. Stomach contents from Dolly Varden revealed that the compositions of organisms in the stomachs was not representative of the composition in the benthos (Table 9). Fish sampled from debris free areas consumed similar proportions of Chironomidae and Plecoptera, but did not consume representative proportions of Ephemeroptera and Trichoptera. It appears that Dolly Varden feed selectively on Trichoptera in debris free areas. This may be due to the large size of the animal (approximately 15-20 mm) and to its riffle dwelling existance that allows the organism to be exposed to predation.

Fish captured in debris laden areas showed a preference for Chironomidae and consumed more than occurred in the benthos, but had a negative preference for Ephemeroptera, Plecoptera, and Trichoptera.

Table 9. Percent Composition of Food Organisms Ingested by Dolly Varden in Spring Pond Creek Compared to the Composition of the Benthic Fauna, 1973.

	Ephemeroptera		Plecoptera		Trichoptera		Diptera		
	No.	% Comp.	No.	% Comp.	No.	% Comp.	No.	% Comp.	N
Benthos Samples									
Gravel Substrate	89	11.79	83	10.99	39	5.16	544	72.06	10
Organic Substrate	38	5.66	45	6.71	44	6.55	544	81.08	14
Organisms Consumed									
Gravel Substrate	12	4.42	28	10.29	34	12.50	198	72.79	12
Organic Substrate	14	.68	19	.92	38	1.86	1983	96.54	14

Seasonal Changes in Food Comsumption

Analysis of the number of food organisms consumed by Dolly Varden during the season shows that mean consumption of food items per fish decreased from 78.3 organisms/fish in May to 4.8 in December:

	May	June	September	October	November	December
Organisms/fish	78.3	66.6	18.0	5.6	5.8	4.8
Number of Fish Samples	21.0	3.0	23.0	12.0	7.0	10.0

This decrease has been noted for both Dolly Varden and to a lesser extent for coho in Hood Bay Creek (Armstrong and Elliott, 1972) and for Atlantic salmon, *Salmo salar*, by Allen (1941). Both decreased food consumption and lowered rate of metabolism initiated by low water temperatures may be a factor in hiding behavior observed in Spring Pond Creek.

Aquatic Insect Surveys in Southeast Alaska

Little collecting was done by this project during the 1973 field season. Almost all of the aquatic insect investigation this year was part of a cooperative effort with project G-I, Inventory and Cataloging of the Sport Fish Waters in Southeast Alaska.

Information on aquatic insect faunas of various Southeast Alaska watersheds will be presented in the 1973-1974 annual report of project G-I.

Ice Formation

Severe icing conditions in a stream can have detrimental effects on the fish and aquatic insect populations.

Mortality to fish populations can result from dewatering of side channels by ice dams (Maciolek and Needham, 1952), sudden collapse of snow and ice into the channel (Needham and Jones, 1959), as will as actual suffocation of fish by floating ice crystals (Tack, 1938). Also, Finni (1973) reports that certain icing conditions can cause a retardation in aquatic insect emergence.

There are three basic types of ice formation in streams: surface, anchor, and frazil ice.

Surface ice forms when the temperature of a quiet body of water reaches 0° C (Barrows and Horton, 1907). Surface ice almost always begins to form at the shore or borders of solid objects. Surface ice can also form over smooth flowing water, however, as the velocity and turbulence of the current increases the ice forms at a slower rate. The formation of opaque surface ice can have detrimental effects on the aquatic environment. In standing bodies of water, formation of surface ice can reduce light penetration which can result in a lowering of dissolved oxygen (Ruttner, 1952). Reimers (1957) reports that prolonged snow cover on surface ice reduces bottom grazing organisms important as trout food. On the other hand, Gard (1963) states that snow cover can have a beneficial effect by protecting aquatic organisms from extreme cold and sub-surface ice. Aquatic insect emergence can also be retarded by surface ice accumulation (Finni, 1973).

Anchor ice, as its name implies, forms on the stream bottom or objects under the water surface. Its formation results from transmission of heat by radiation (Hoyt, 1913). Anchor ice forms chiefly during cold clear nights and most rapidly on dark colored surfaces. It is never found under opaque surface ice cover or structures such as bridges.

Barnes (1906) reports anchor ice carrying large chunks of stream bottom aggregate downstream. This transportation of bottom material can cause destruction of eggs andalevins through annihilation of spawning redds; however, this same activity can cause dislodgement of bottom organisms, making them available as fish food (Needham and Jones, 1959). Benson (1955) reports such distribution of bottom organisms in a Michigan stream by floating anchor ice.

Dewatering of side channels by the formation of anchor ice dams can cause suffocation to fish trapped in these areas (Maciolek and Needham, 1952). Minor flooding can occur when these dams break, but it is generally felt these floods cause less disturbance than normal freshets.

Frazil ice (from the French Canadian term for fine spicular ice) forms throughout the water column as minute, irregular crystals (Maciolek and Needham, 1952). It never forms under opaque surface ice and usually occurs in greatest accumulations on cold, clear, windy nights when the water surface is agitated.

Drifting frazil ice often tends to accumulate on anchor and/or surface ice, thus creating ice dams which can cause the problems discussed previously. However, the most direct detrimental effect frazil ice can have upon fish is that observed by Tack (1938). Tack reports that particles of drifting frazil ice actually became lodged in the gills of rainbow fingerlings being held in an outdoor rearing pond. The ice accumulation was severe enough to cause about one hundred mortalities.

Ice Observations at Starrigavin Watershed:

Icing conditions were initially observed at Starrigavin watershed on October 17 in the form of this surface ice on the side channels of the main stream.

A rise in air temperature (Fig. 8) retarded further icing until November 5, on which date surface ice was first observed on Spring Pond.

By November 7, the surface ice on the side channels of the main stream was 7.5 cm thick. The following day the surface ice had increased to 6.2 - 9.2 cm in thickness and rearing coho were observed beneath the ice swimming freely.

The first snow fall (approximately 5 cm) occurred on November 11, and resulted in the melting and collapsing of most of the ice cover present.

Throughout the remainder of the monitoring period fluctuating air and water temperatures (Fig. 8) resulted in repeated freezing and thawing

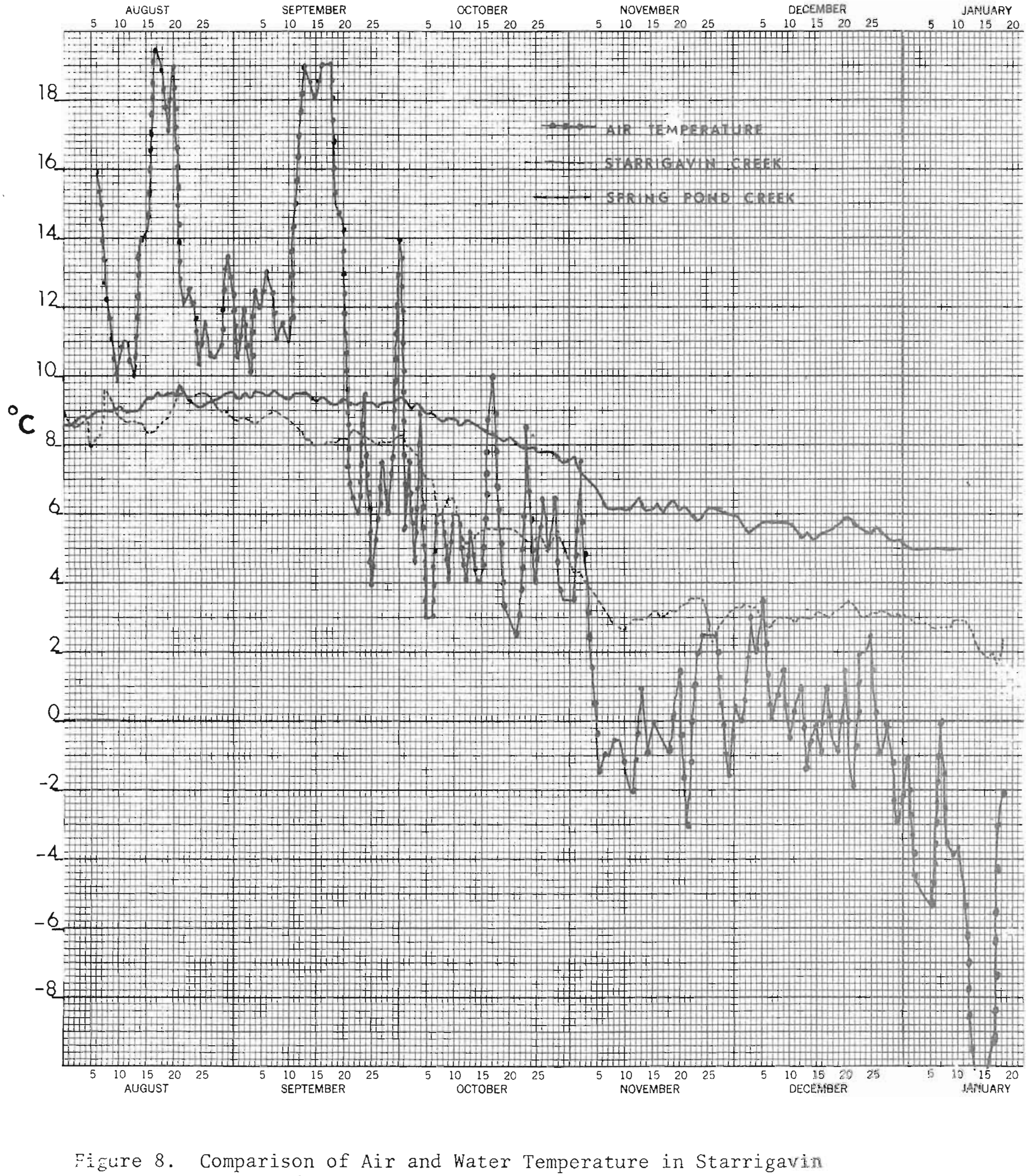

Figure 8. Comparison of Air and Water Temperature in Starrigavin Watershed, 1973-1974.

conditions. Following the sub-freezing temperatures in late December, the surface ice on Spring Pond (January 4) was measured and found to range from 3.9 cm to 12.3 cm thick.

During the extremely cold air temperatures (down to -13° C) of January 13-15, the main stream was completely covered with surface ice (ranging up to 12 cm thick) for the first time. Surface ice was also observed covering Spring Pond Creek in several places.

At no time did Spring Pond Creek freeze solid or flow underground. However, the two other monitored tributaries, which are not spring-fed (Coho Creek and Skunk Cabbage Creek), were either completely covered with thick (3-4 cm) surface ice, flowing underground, or frozen to the substrate on three separate occasions during the observation period.

Frazil and anchor ice were not observed during the winter though the conditions required for its formation ocurred several times.

Minnow Traps as a Population Estimator

Due to conflicting field schedules, the ability of minnow traps to make a reliable population estimate was only tested three times. The total fish captured by species and the percent marked captured by minnow traps and back-pack shocker are compared in Table 10.

Even though the number of repetitions was extremely small, the results seem to indicate that the minnow traps could give relatively reliable population estimates.

The portability of the minnow traps, as well as the advantage of being able to utilize them in debris choked areas where shocking is not feasible, weighs heavily in the favor of them as a field estimator of fish populations. Though they may lack the accuracy of a shocker, field conditions encountered could dictate the minnow trap method as an alternative.

Table 10. Total Fish Captured and Percent Marked. Captured by Species with Minnow Traps and Back-pack Shocker.

	Minnow Traps			Shocker		
Test	Total Captured		Marked	Total Captured		Marked
I	Coho	30	13%	Coho	94	7%
	Dolly Varden	25	13%	Dolly Varden	34	15%
II	Coho	67	10%	Coho	27	7%
	Dolly Varden	26	7%	Dolly Varden	75	12%
III	Coho	44	23%	Coho	62	21%
	Dolly Varden	27	19%	Dolly Varden	22	5%

DISCUSSION

The Effects of Debris on the Aquatic Environment

Many authors have documented the possible effects of detrital material on the aquatic environment.

It has been shown by Briggs (1949) that riffle areas with gravel substrates produce greater weights and numbers of benthic organisms than do pools, and that when gravel interstices are filled with material, there is a loss of habitat for cryptic animals, such as Ephemeroptera and Plecoptera (Bornaud in Hynes, 1970; Chutter, 1969).

Emergent detritus from logging also impedes water flow allowing debris to settle and prevents the natural flushing action of the stream from removing the material. Lowered water velocity can affect aquatic forms such as riffle dwelling Ephemeroptera that depend on the movement of water over gill surfaces for respiration (Dodds and Hisaw, 1924; Feldmeth in Sinha, 1971). Impoundment and decay of organic material may depress the level of dissolved oxygen (Lantz, 1971), leading to mortality or inability of some Ephemeroptera to complete the transition from the nymphal to adult form (Nebeker, 1972).

Allochthornous leaf fall, especially of the deciduous type, may serve as the basic energy source in stream ecosystems (Chapman and Demory, 1963; Minshall, 1967) by serving as food for aquatic insects and nutrient source for phytoplankton.

Undoubtedly the coniferous detrital material in Spring Pond Creek serves as food source for many of the benthic organisms. Observations of gut samples in aquatic insects indicates that some of the chironomids, *Nemoura* sp., *Capnia* sp., and possibly *Cinygmula* sp., consume fine particles of coniferous detrital material. It is also apparent that there are differences in faunal composition between debris covered areas and those that are not. This may possibly be due to the presence of organisms which are specifically detrital feeders and those that are periphyton grazers. It is conceivable that detrital feeders live both in debris covered areas and gravel areas, while periphyton grazing organisms require clean substrates and can only exist in areas free of gravel.

We have found no indication that the fauna of altered sections of the stream has any undesirable effect on fish production, e.g., slower growth rate, though it is apparent that feeding habits of fish collected from debris areas is different from those in gravel areas. Observations on the size of organisms occupying these types of habitat indicates that the fauna of natural areas are generally larger and more exposed to predation by fish than animals living in detrital ooze. However, Mundie (1973) found that gravel substrates enriched with organic material (grain) produces a greater total weight of aquatic organisms than does natural gravels, and Warren, et al (1964) showed that enrichment of streams with sucrose increased both invertebrate and trout production.

Winter Distribution and Behavior of Dolly Varden and Coho

Rearing Dolly Varden, *Salvelinus malma*, and coho, *Oncorhyncus kisutch*, were frequently observed and trapped during the summer months in Spring Pond Creek; and it was found that in the winter, even during the coldest weather, fish could be trapped. However, though fish were present in large numbers, they were never seen or observed moving. Trap sets revealed that fish appear to congregate in the deeper areas of the stream such as Spring Pond and in Ryan Pool. Both rearing char and coho also appear to overwinter in dense tangles of logging slash and debris and may possibly burrow into this material. The decline of water temperatures to about 5°-6° C initiated hiding behavior of chinook salmon, *Oncorhynchus tshawytscha*, and steelhead trout, *Salmo gairdneri*, in Idaho streams (Chapman and Bjornn, 1969), and Bustard (1973) found that as temperatures declined from 9° C to 2° C, steelhead and coho moved into areas providing cover, particularly overhanging banks offering exposed root systems.

Observation of Dolly Varden and coho at Spring Pond Creek indicate that fish develop hiding behavior at about 4°-2° C. During January and February fish were never seen in either Spring Pond Creek or in the main stream where temperatures approached 0.5° C. However, as water temperatures began to rise, fish were observed in both the main stream and side tributaries as the temperature approached 2° C.

Armstrong (1974) and Blackett (1968) have shown that spawning populations of Dolly Varden will often move into lakes to overwinter. A small portion of the in-migrant chars captured at the Spring Pond Creek weir were sexually mature residents and anadromous forms. These fish presumably spawned in gravel areas of Spring Pond Creek but did not move out of the stream after spawning and return to the main stream.

Evidently most of the fish overwintered in Spring Pond Creek as several individuals were captured with a surbur sampler when taking insect samples in slash and debris laden areas.

Fall Movement of Dolly Varden and Coho

Chapman and Bjornn (1969) have shown that juvenile chinook and steelhead often move downstream and enter larger rivers as temperatures decline during the fall. Bustard (1973), Skeesick (1970), and Goodnight and Bjornn (1971) found that juvenile coho and young brook trout, *Salvelinus fontinalis*, leave the main stream and assume residence in tributary streams during the winter.

Fall migration of juvenile Dolly Varden and coho into Spring Pond Creek appears to take place in September and October. These fish originate from downstream sources and move in a general upstream direction before residing in tributary streams for the winter.

There is undoubtedly a survival benefit to overwintering in spring-fed tributary streams where the effect of freshets and flooding are less prone to cause mortality (Lister and Walker, 1966) and water temperatures are usually warmer. Hunt (1969) found that overwinter survival of juvenile brook trout was higher when water temperatures were warmer during the winter months, and Bustard (1973) has calculated that 76% of 355 in-migrating juvenile coho in a groundwater-fed tributary of Carnation Creek survived the winter months and returned to the main stream in May.

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